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Book of Abstracts
November 2-5, 1998

Kellie Ann Beall, Editor

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Gaithersburg, Maryland 20899

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U.S. Department of Commerce
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An Integrated Modeling of Water Mist Penetration Through Obstructions

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The use of fine water mist as a possible Halon 1301 replacement for certain fire suppression applications has been discussed by Jones and Nolan [1] and by Ramsden [2]. One current research effort is to apply the water mist sprays to suppress the fire occurring in hidden location behind obstructions or inside the equipment compartments. This study presents an integrated approach to model the penetration of water mist through the obstructions for fire suppression applications. The objective is to reveal the transport mechanisms, impacting dynamics, and penetration of mist droplets through the obstructions during fire situations.

Since the mist usually contains a spectrum of drop sizes, the smaller mist droplets may follow the gas streams closely and penetrate directly through the slots of the obstructions while the larger droplets may be intercepted or impacted by the obstructions. Figure 1 displays the schematic of the mist flow in the vicinity of an obstruction. When the mist droplets are approaching the structures, the overall penetrating process of the mist flow through the obstruction depends strongly on the transport of the mist droplets in the gas streams, the ability of the droplets flowing through the obstruction, and the behavior of droplets subsequent to the impaction.

Numerical simulations of a two-phase gas droplet flow based on Navier-Stokes equations are performed to study the transport of mist droplets around a rectangular strip obstruction. The penetration of fine mist droplets is not straight forward because their trajectories approaching the obstruction might be deviated due to the aerodynamic effects. In general, the amount of mist penetrating would depend upon the incoming drop size and the speed of approach. Therefore, a non-dimensional impaction parameter (K) is used to determine the amount of mist arriving the obstruction. The collection efficiency (η) is correlated with this K parameter to determine the amount of droplets to be captured by the obstruction. Then, the by-passing droplets through the adjacent slots of the obstruction can be accounted for by the penetration efficiency (α) which is formulated based on the collection efficiency and the geometric fraction of the obstruction to the flow domain configuration. In addition, the flow wake in the form of vortex shedding at the downstream of the obstruction would affect the motions of the droplets which have already penetrated. Based on the above numerical analysis, it seems that fine water mists may be preferred in suppressing certain hidden fire situations because they have a better ability to follow air streams closely with higher penetration efficiency. A general methodology has been reported by Hung and Yao [3].

Experimental investigations are also accomplished to study the actual droplet impacting phenomena on the obstruction. Typical obstruction objects such as the single wires [4,5] and complex wire screens [6] are considered in details in the impaction experiments. A portion of the mist intercepted by the obstruction may build up liquid films and subsequently penetrate in a different form. Images of the impacting phenomena based on digital image processing demonstrate that the impacting phenomena generally include dripping and disintegration. The results have been correlated in non-dimensional forms with the incoming droplet Weber number, wire Bond number, drop to wire diameter ratio, and

[1] Currently with the Delphi Automotive Systems, Rochester, New York

screen number. Non-dimensional regime maps and the correlations of the impaction outcome are also developed. The conclusions from both the numerical and experimental investigations are integrated to provide an overall understanding to the mist penetration phenomena and to establish a procedure for predicting the outcome of this process.

Acknowledgment

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Reference

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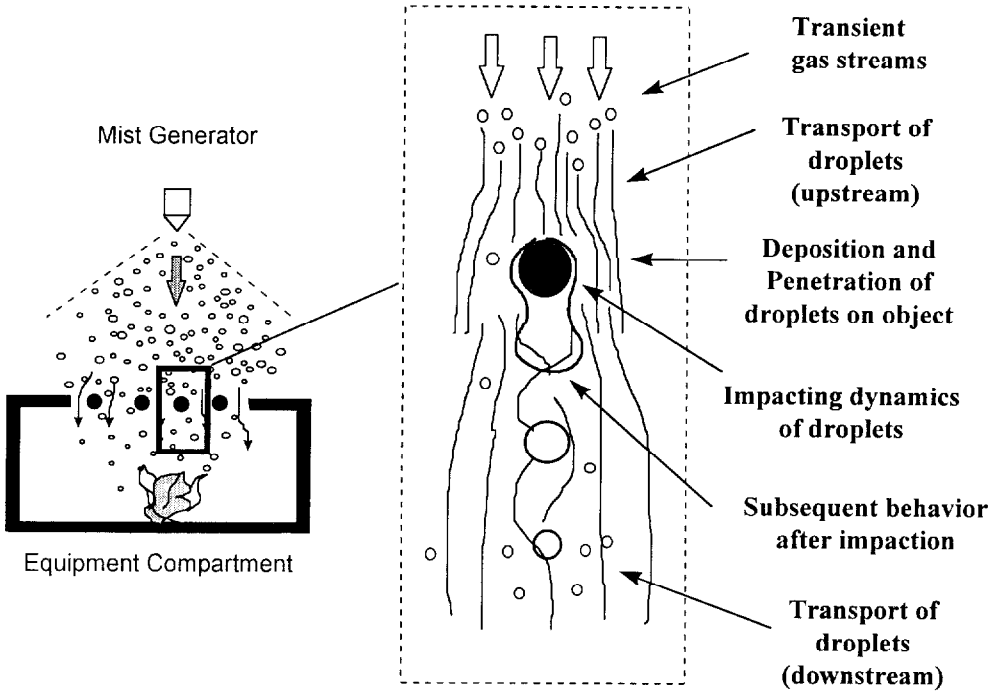

Figure 1 ***A schematic of water mist penetrating through the opening slots of the obstruction***